



## • NASA DATA SYSTEM STANDARDS PROGRAM •

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Session D (08:30 – 12:00):

# Standards Development Activities – The NASA Standardization Program

*Session Chair: Andy Downen (NASA-HQ)*

1. Interplanetary Internet: An Architectural Framework for Space Internetworking: Adrian Hooke
  2. User Data Services for Internet Based Spacecraft Applications: Joe Smith
  3. CCSDS File Delivery Protocol (CFDP): Tim Ray
  4. Internet Protocol Based Standards for Spacecraft Onboard Interfaces: Joe Smith
  5. Standard Spacecraft Interfaces and IP Network Architectures: Jane Marquart
  6. Standard Transport and Network Capabilities: Bob Durst
  7. Next Generation Space Internet: Standards and Implementation: Keith Scott
  8. Secure Space Networking: Howie Weiss
  9. Delay Tolerant Networking: Scott Burleigh
  10. CCSDS Link Layer Protocol Suite: Greg Kazz
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# **Interplanetary Internet: an architectural framework for space internetworking**

04 June, 2003

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NASA Jet Propulsion Laboratory  
California Institute of Technology  
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# AGENDA

- ◆ History and rationale
- ◆ An overview of the protocol suite
- ◆ Next steps



1970

1980

1990

2000

NASA Telemetry Standardization

"Packet" Spacecraft  
Telemetry and Telecommand



02 January, 1996  
STRV-1b  
IP address:  
192.48.114.156

Basic Space/Ground  
Communications  
Standards for  
Space Missions

NASA/ESA  
Working Group

CCSDS Link baselined by Space  
Station and Ground Network



Consultative Committee for Space Data Systems (CCSDS)

CCSDS Recommendation for  
Advanced Orbiting Systems

Extension of  
Standards for  
More Complex  
Space Missions

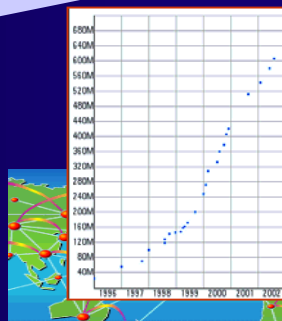
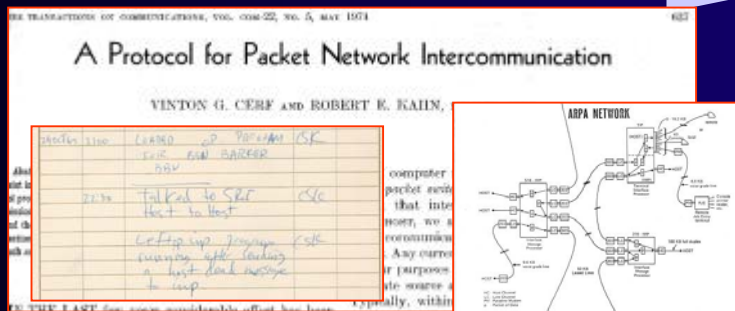
International Space Station

CCSDS Space Link  
+File Transfer: FTAM  
+Transport: TP4  
+Network: ISO 8473

"The  
Dark  
Age  
of  
GOSIP"

Extension of the  
Terrestrial Internet  
into Space

Evolution of space standards



NASA/DOD/CCSDS  
Space Communications  
Protocol Standards  
(CCSDS-SCPS) Project

File Transfer: FTP  
Transport: TCP  
Network: IP

2002:  
605  
million  
users

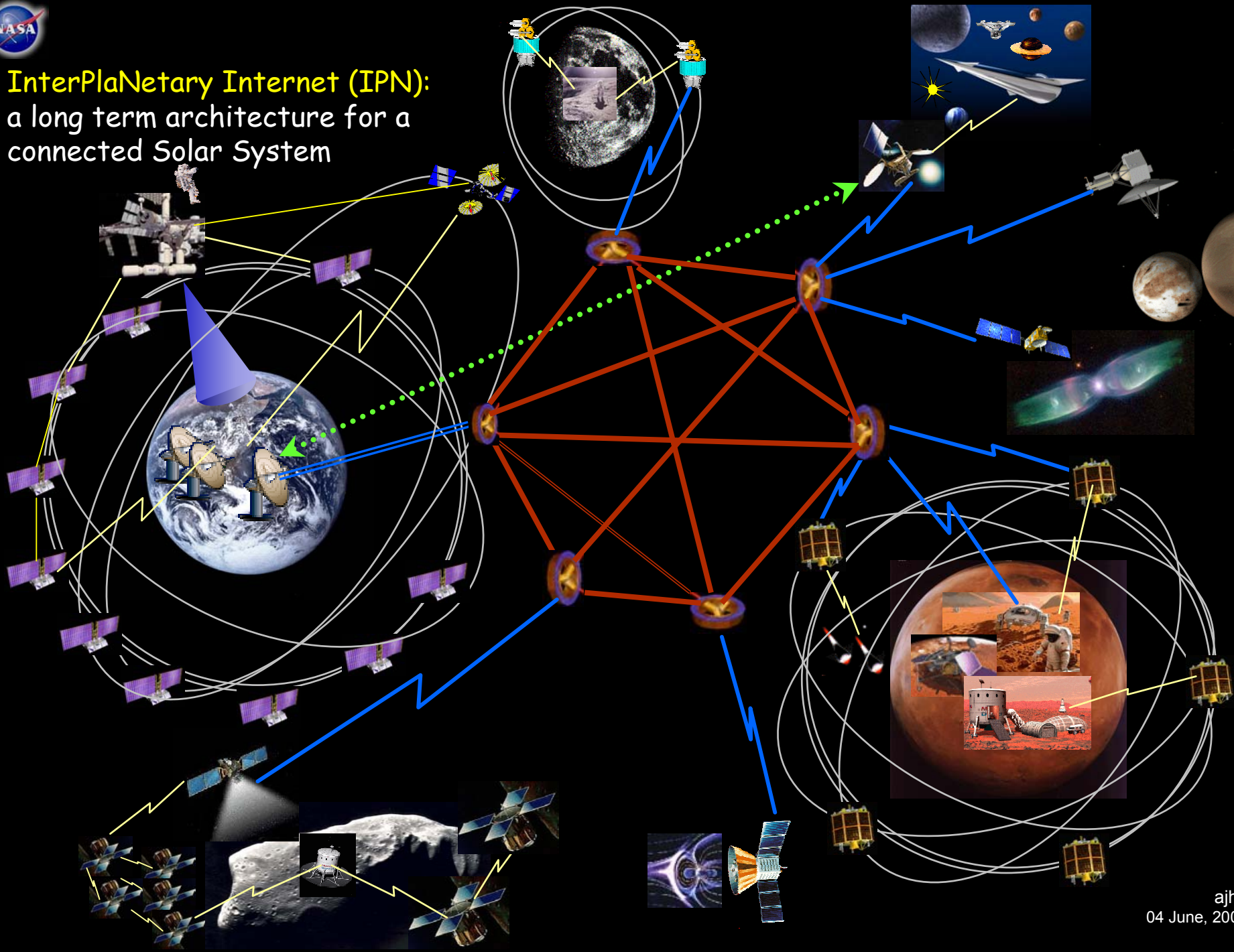
InterPlaNetary  
Internet (IPN)



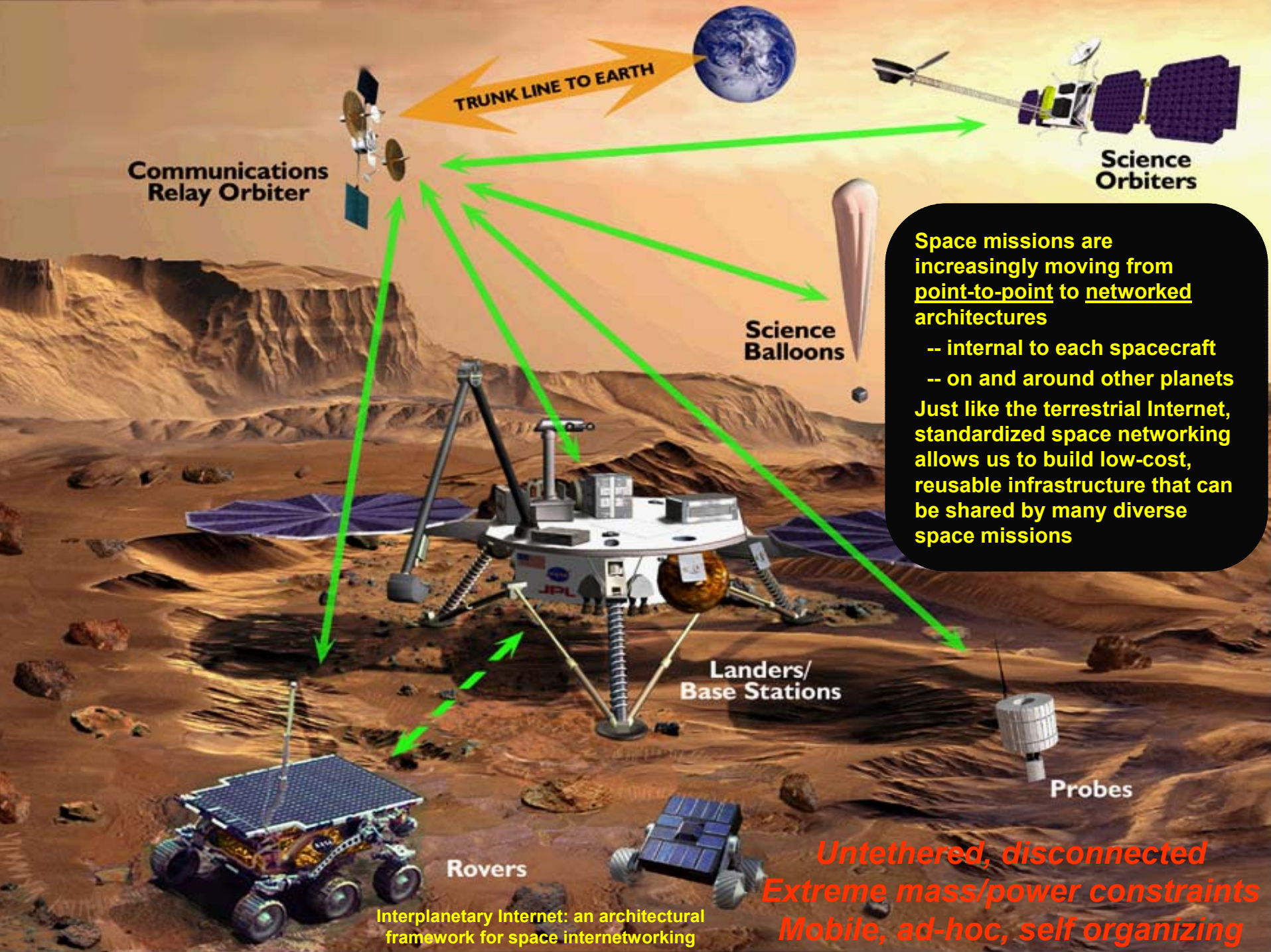
Evolution of the terrestrial Internet



# InterPlaNetary Internet (IPN): a long term architecture for a connected Solar System







Communications  
Relay Orbiter

TRUNK LINE TO EARTH

Science  
Orbiters

Science  
Balloons

Landers/  
Base Stations

Probes

Rovers

Interplanetary Internet: an architectural  
framework for space internetworking

Space missions are  
increasingly moving from  
point-to-point to networked  
architectures

- internal to each spacecraft
- on and around other planets

Just like the terrestrial Internet,  
standardized space networking  
allows us to build low-cost,  
reusable infrastructure that can  
be shared by many diverse  
space missions

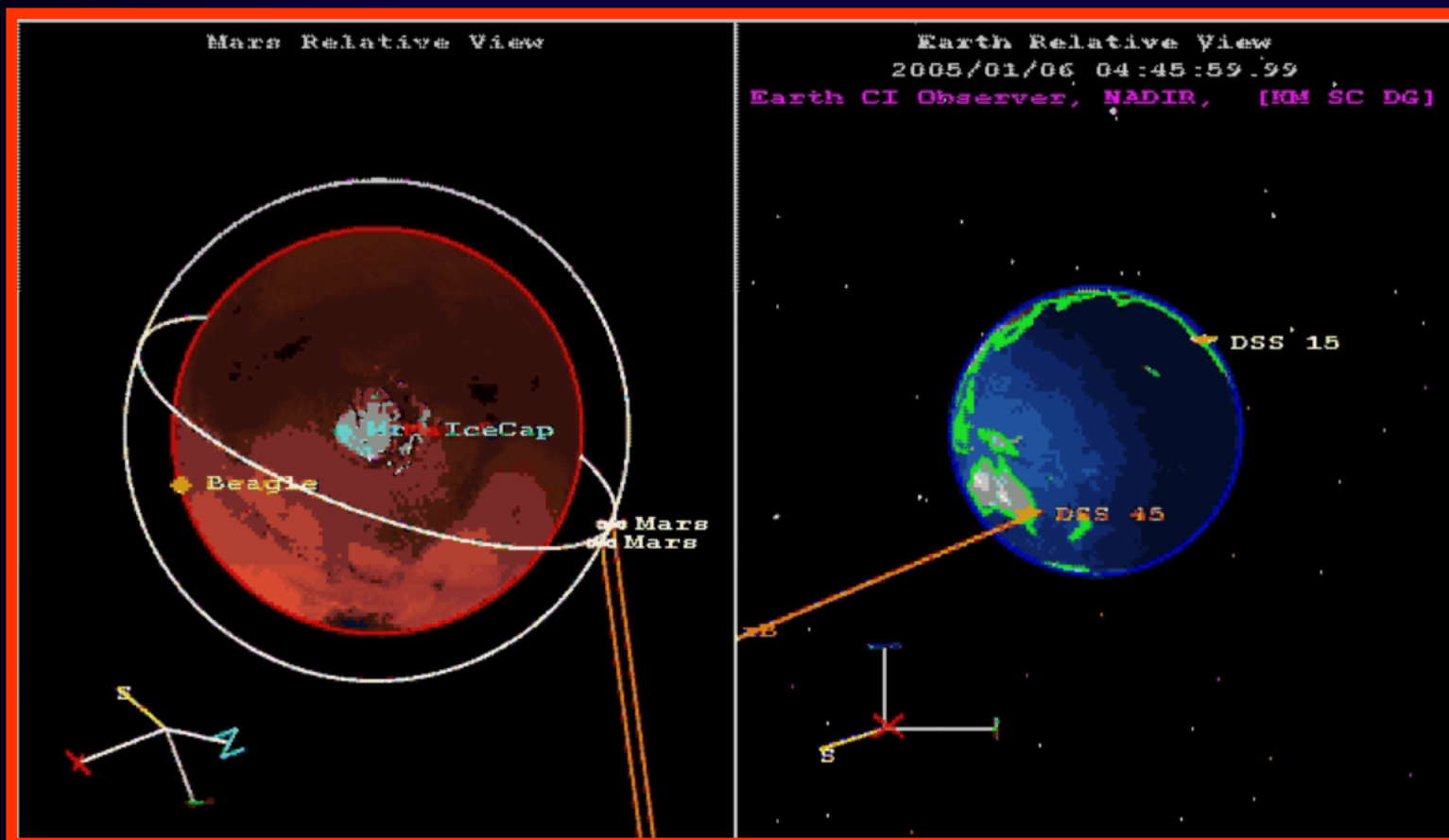
*Untethered, disconnected*  
*Extreme mass/power constraints*  
*Mobile, ad-hoc, self organizing*



The Internet is a connected, chatty '**network of networks**' based on a wired backbone with negligible delay and errors (with untethered "edges" emerging)



The InterPlaNetary Internet is a often disconnected, store-and forward '**network of Internets**' based on a wireless backbone with huge delays and error prone links

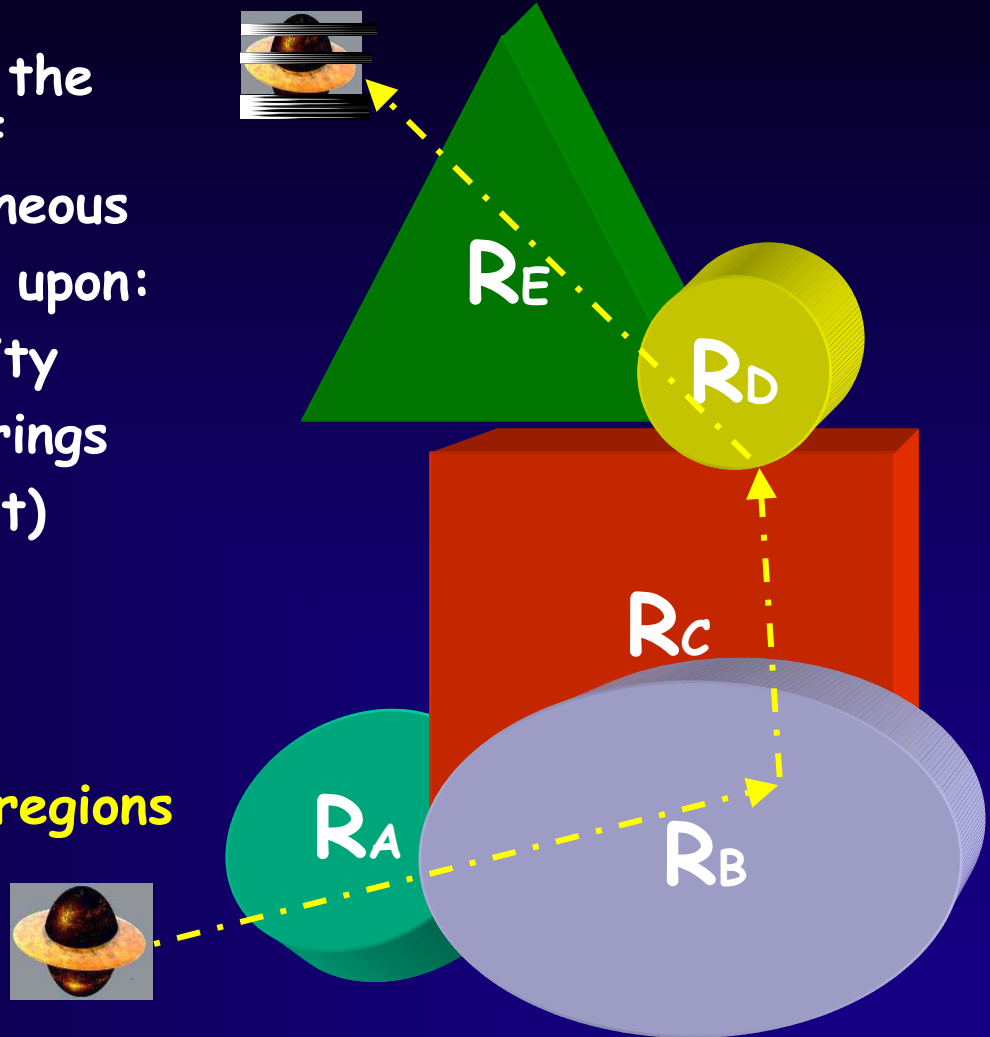




# The Interplanetary Internet

*an overlay network for interconnection of **regional internets***

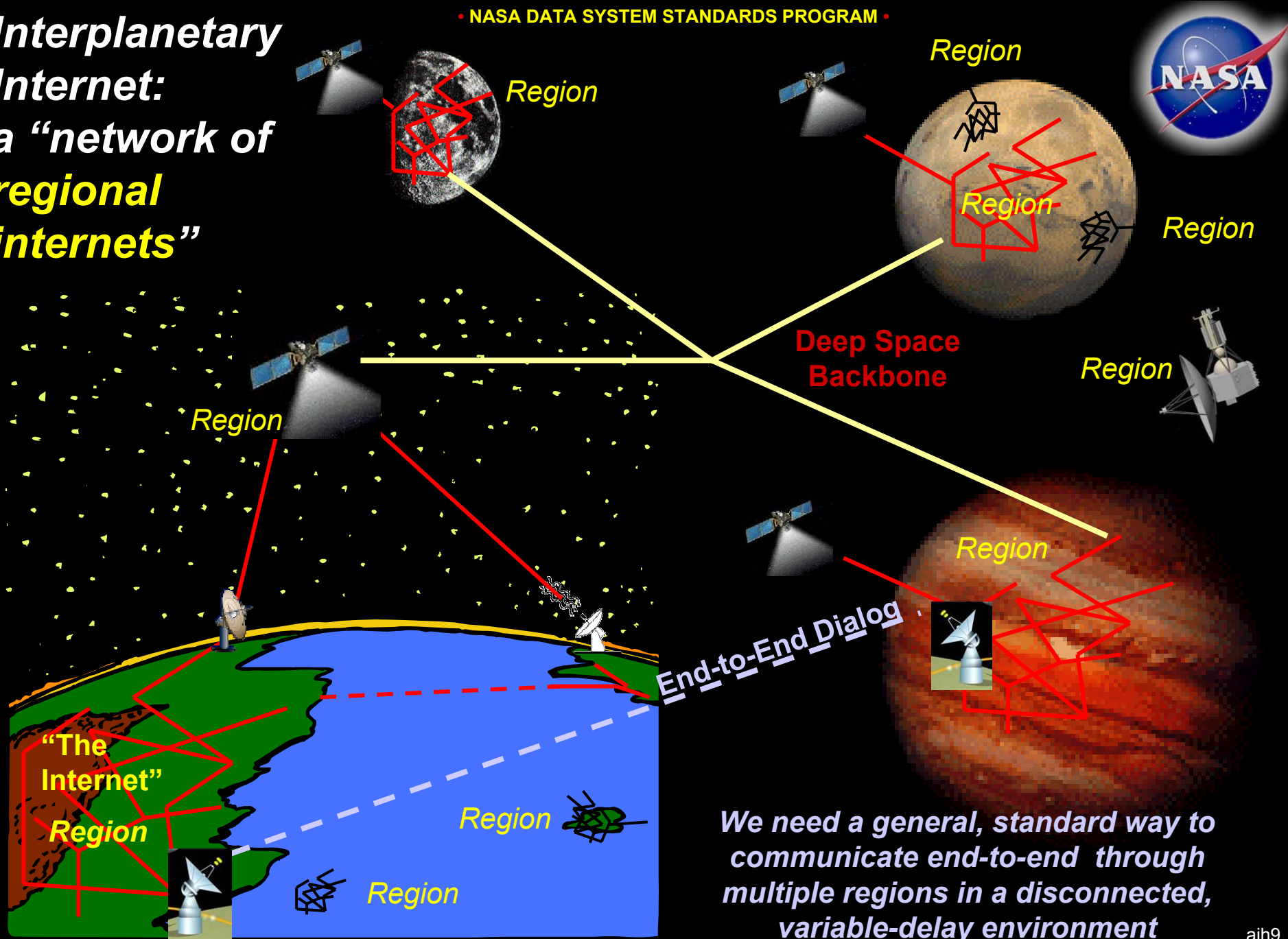
- ♦ A **region** is an area where the relevant characteristics of communication are homogeneous
- ♦ **Regions** are defined based upon:
  - ❖ Communications capability
  - ❖ Quality of Service Peerings
  - ❖ Security (levels of trust)
  - ❖ Degree of resource management
  - ❖ Etc.
- ♦ Traversal of two or more **regions** will affect the nature of communications





# Interplanetary Internet: a “network of regional internets”

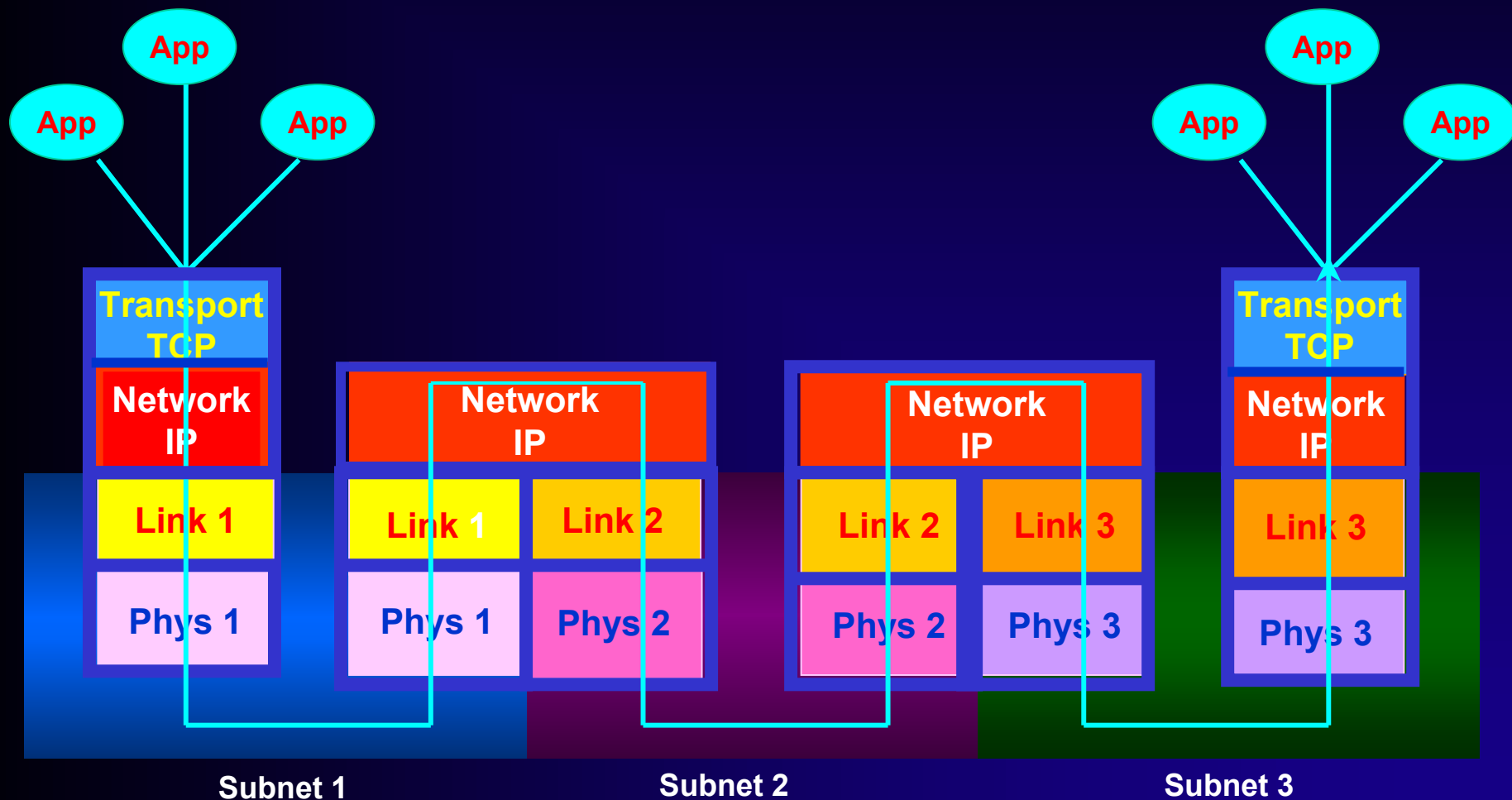
• NASA DATA SYSTEM STANDARDS PROGRAM •



*We need a general, standard way to  
communicate end-to-end through  
multiple regions in a disconnected,  
variable-delay environment*



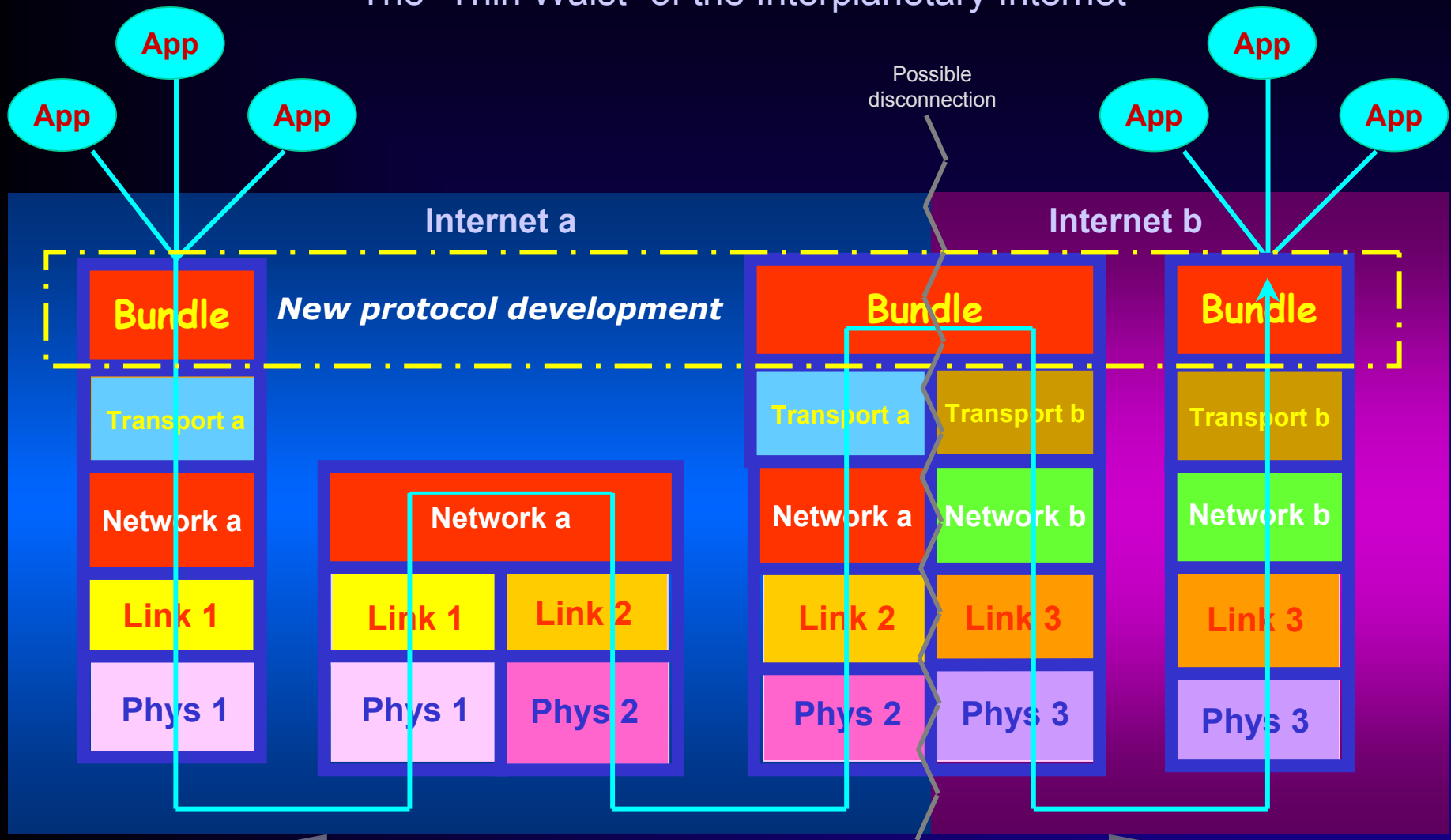
## *The Internet: a Network of Connected Sub-Networks*





# Bundles: a Store and Forward Application Overlay

The “Thin Waist” of the Interplanetary Internet

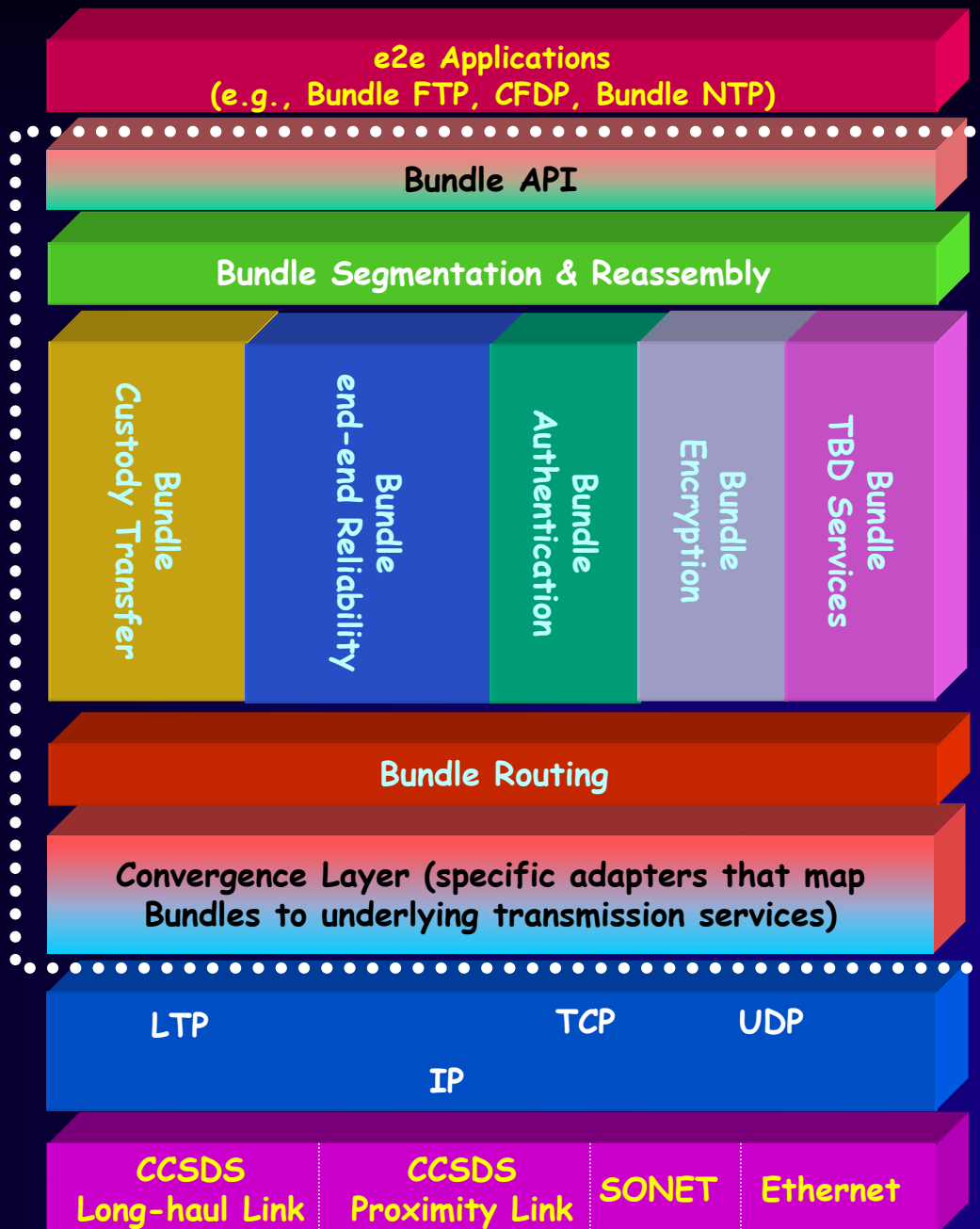


A “network of internets” spanning dissimilar environments

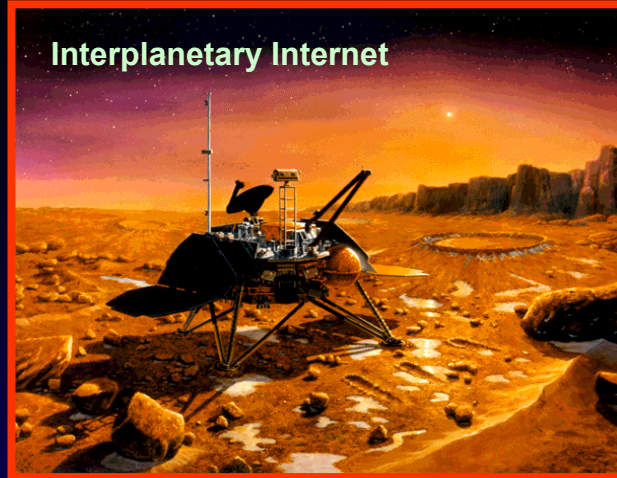
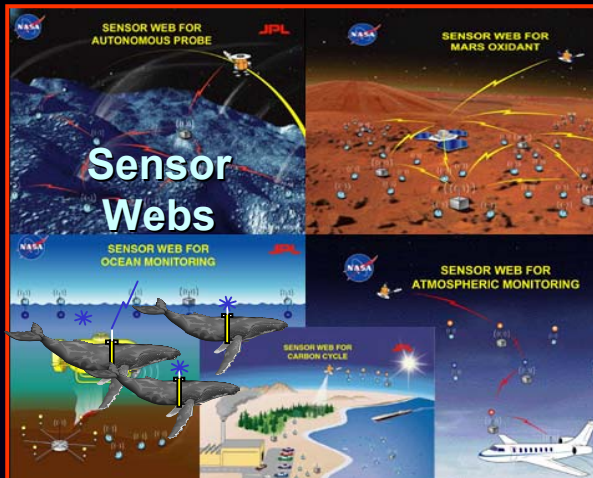


# Bundle Service Layering

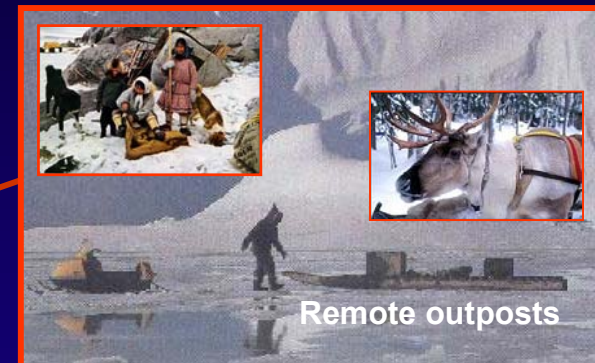
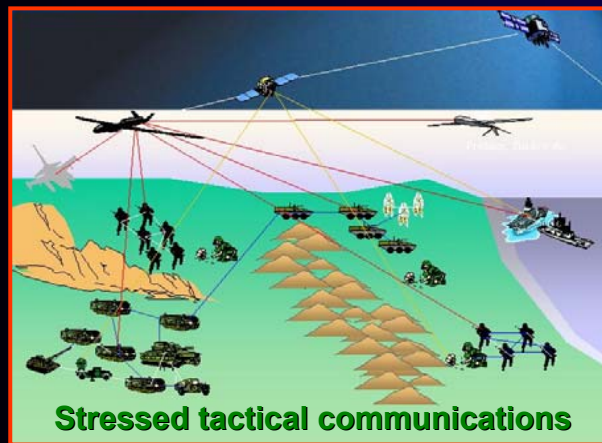
“Bundles”







- ◆ “Non-chatty” message-oriented communications
- ◆ Store-and-forward between nodes
- ◆ Routing algorithms cognizant of scheduled connectivity
- ◆ Use transport and network technologies appropriate to the environment
- ◆ Integral infrastructure protection



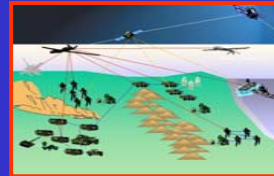
<http://www.dtnrg.org>  
[dtn-interest@mailman.dtnrg.org](mailto:dtn-interest@mailman.dtnrg.org)



**IPN evolution:**  
 Broader applicability  
 Nearer term utility  
 Larger research community



## DARPA Advanced Technology Office



Fielded  
deployments of  
DTN technology

2002

2003

2004

2005

### DTN Research Group:

**Focal point  
for DTN**



DTN Core Engineering

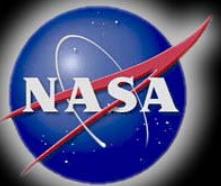
- ◆ DTN Architecture
- ◆ DTN Design Documents

DTN Open Source

- ◆ Reference Software
- ◆ Configuration Control

DTN Standardization

- ◆ International Standards



DTN Research Group  
 INTERNET-DRAFT  
 May 2001  
 Expires November 2001

V. Cerf  
 Wozniak/Jet Propulsion Laboratory  
 S. Burleigh  
 A. Hooke  
 L. Torgerson  
 NASA/Jet Propulsion Laboratory  
 K. Scott  
 The MITRE Corporation  
 K. Taves  
 Global Research and Technology  
 K. Helms  
 SPARTA, Inc.

Interplanetary Internet (IPN): Architectural Interactions  
 draft-ietf-ipn-arch-00.txt

**IPN  
 Architecture  
 (Internet Draft 1)  
 May 2001**

DTN Research Group  
 INTERNET-DRAFT  
 draft-ietf-dtn-arch-01.txt  
 August 2002  
 Expires February 2003

V. Cerf  
 Wozniak/Jet Propulsion Laboratory  
 S. Burleigh  
 A. Hooke  
 L. Torgerson  
 NASA/Jet Propulsion Laboratory  
 K. Scott  
 The MITRE Corporation  
 K. Taves  
 Global Research and Technology  
 K. Helms  
 SPARTA, Inc.

Delay-Tolerant Network Architecture:  
 The Evolving Interplanetary Internet

**DTN  
 Architecture  
 (Internet Draft 2)  
 August 2002**

Bundle Layer Protocol Specification  
 V 0.4  
 9/6/2002

S. Burleigh, V. Cerf, R. Drost, K. Fall, A. Hooke,  
 K. Scott, L. Torgerson, H. Weiss

Table of Contents  
 1. Introduction  
 2. Terminology

**Bundle Protocol  
 Specification, Draft1  
 September 2002**

DTN Research Group  
 INTERNET-DRAFT  
 draft-ietf-dtn-arch-00.txt  
 March 2003  
 Expires September 2003

V. Cerf  
 Wozniak/Jet Propulsion Laboratory  
 S. Burleigh  
 A. Hooke  
 L. Torgerson  
 NASA/Jet Propulsion Laboratory  
 K. Scott  
 The MITRE Corporation  
 K. Taves  
 Intel Corporation  
 K. Helms  
 SPARTA, Inc.

Delay-Tolerant Network Architecture

**DTN  
 Architecture  
 (Internet Draft 3)  
 March 2003**

DTN Research Group  
 INTERNET-DRAFT  
 draft-ietf-dtn-arch-00.txt  
 March 2003  
 Expires September 2003

Robert C. Drost  
 The MITRE Corporation

Delay-Tolerant Networking:  
 An Example Interplanetary Internet Bundle Transfer

**IPN Bundle Transfer  
 (Internet Draft 1) March 2003**

Delay Tolerant Networking Research Group  
 Internet Draft  
 draft-ietf-dtn-arch-00.txt  
 March 2003  
 Expires: September 2003

K. Scott  
 The MITRE Corporation  
 S. Burleigh  
 Jet Propulsion Laboratory

Bundle Protocol Specification

**Bundle Protocol Specification  
 (Internet Draft 1) March 2003**

# Bundle Specification

**Specifications  
 + Code base**

# Bundle Prototyping

**1st. Rough Code  
 August 2000**

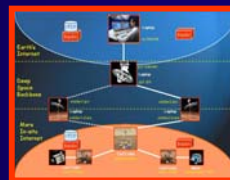
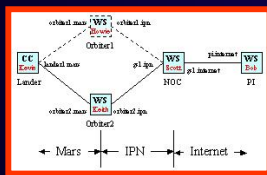
**2nd. Proto. Code  
 May 2002**

**3rd. Proto. Code  
 July 2002**

**4th Proto. Code  
 Sept. 2002**

**5th Proto. Code  
 Nov. 2002**

**Open Source  
 Release1 Code  
 March 2003**

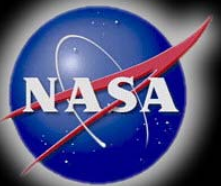


**Code available at <http://www.dtnrg.org>**

Files/Images/UGS-over-  
 Bundles Experiment

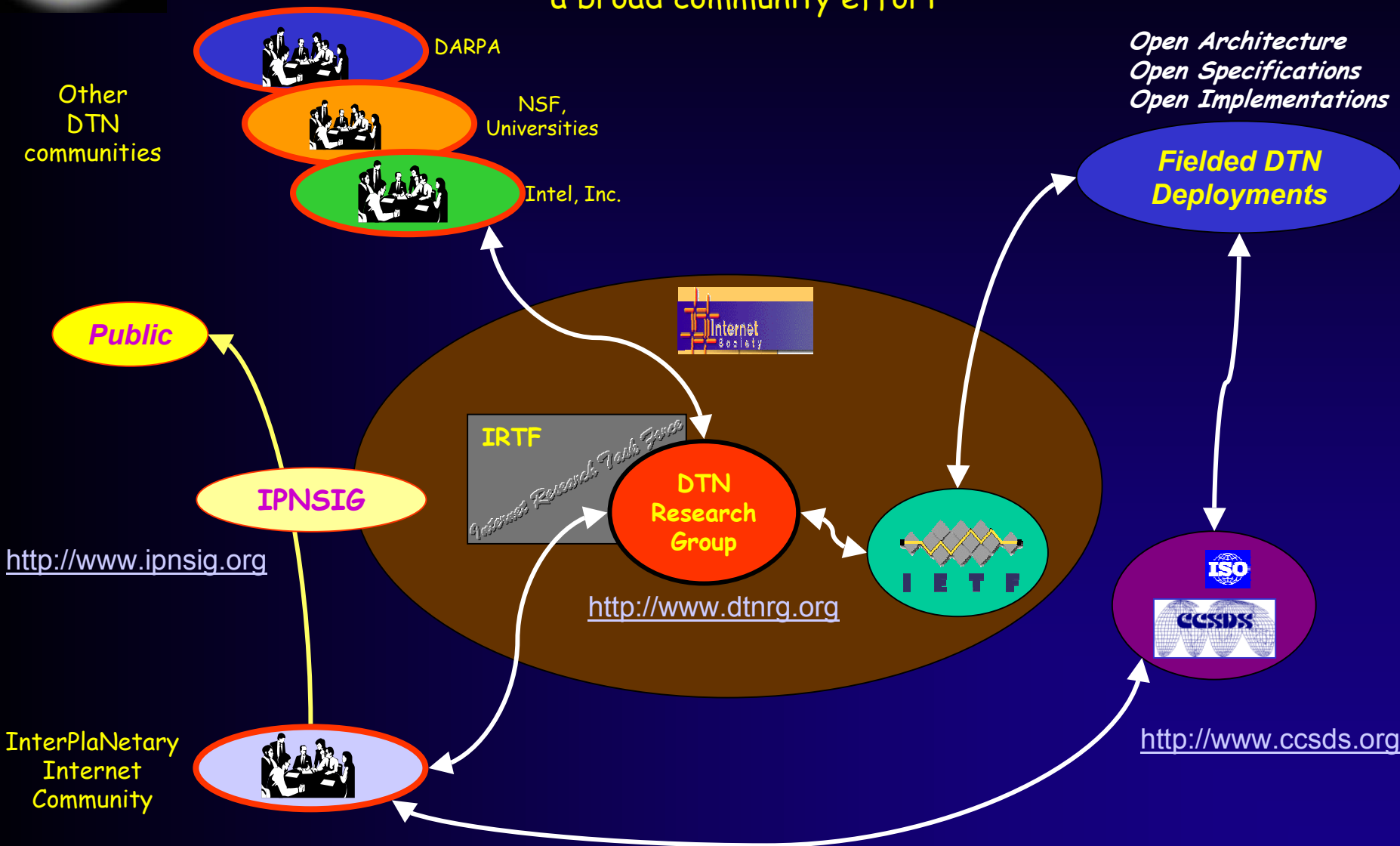
ajh15  
 04 June, 2003





# Delay Tolerant Networking:

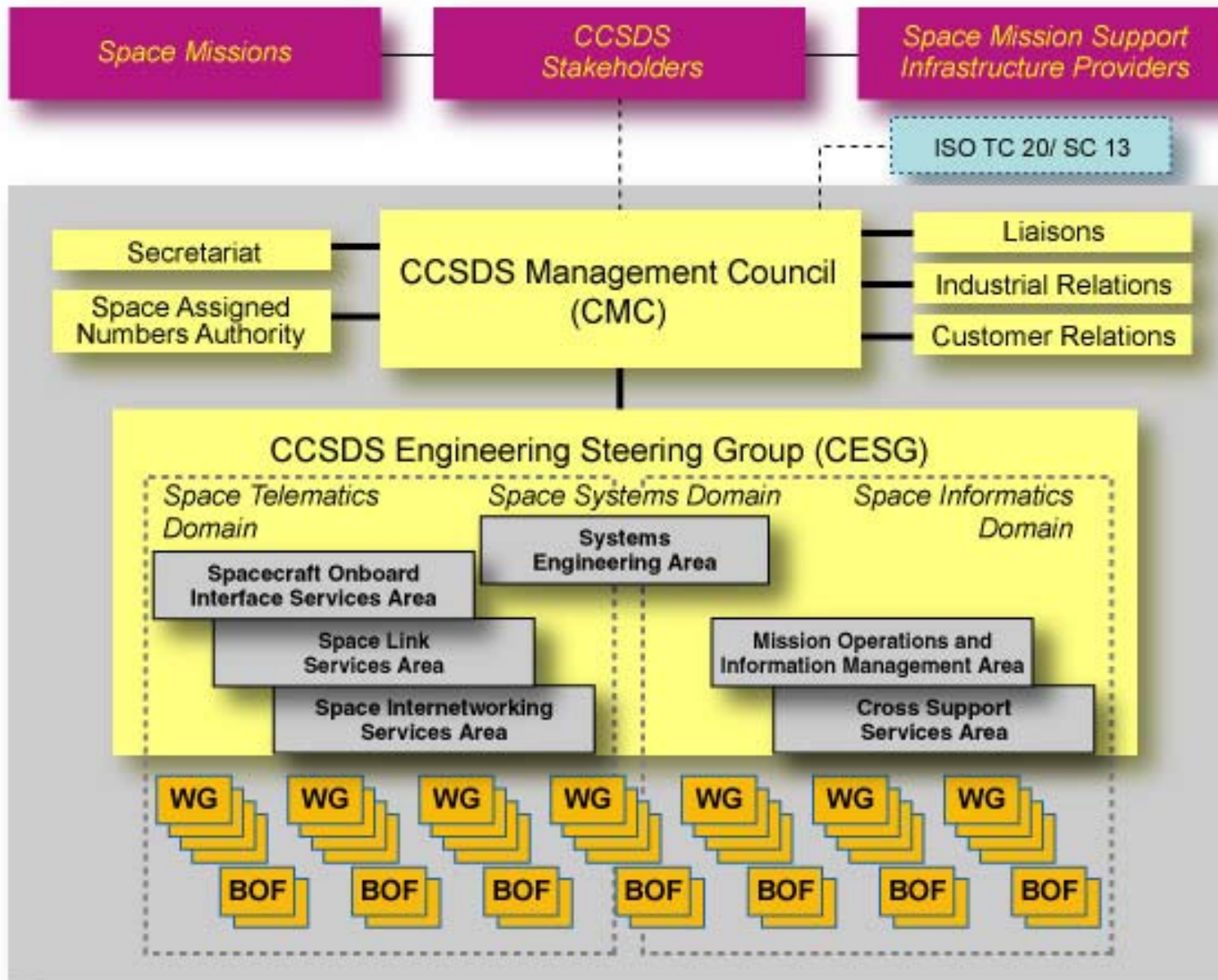
a broad community effort





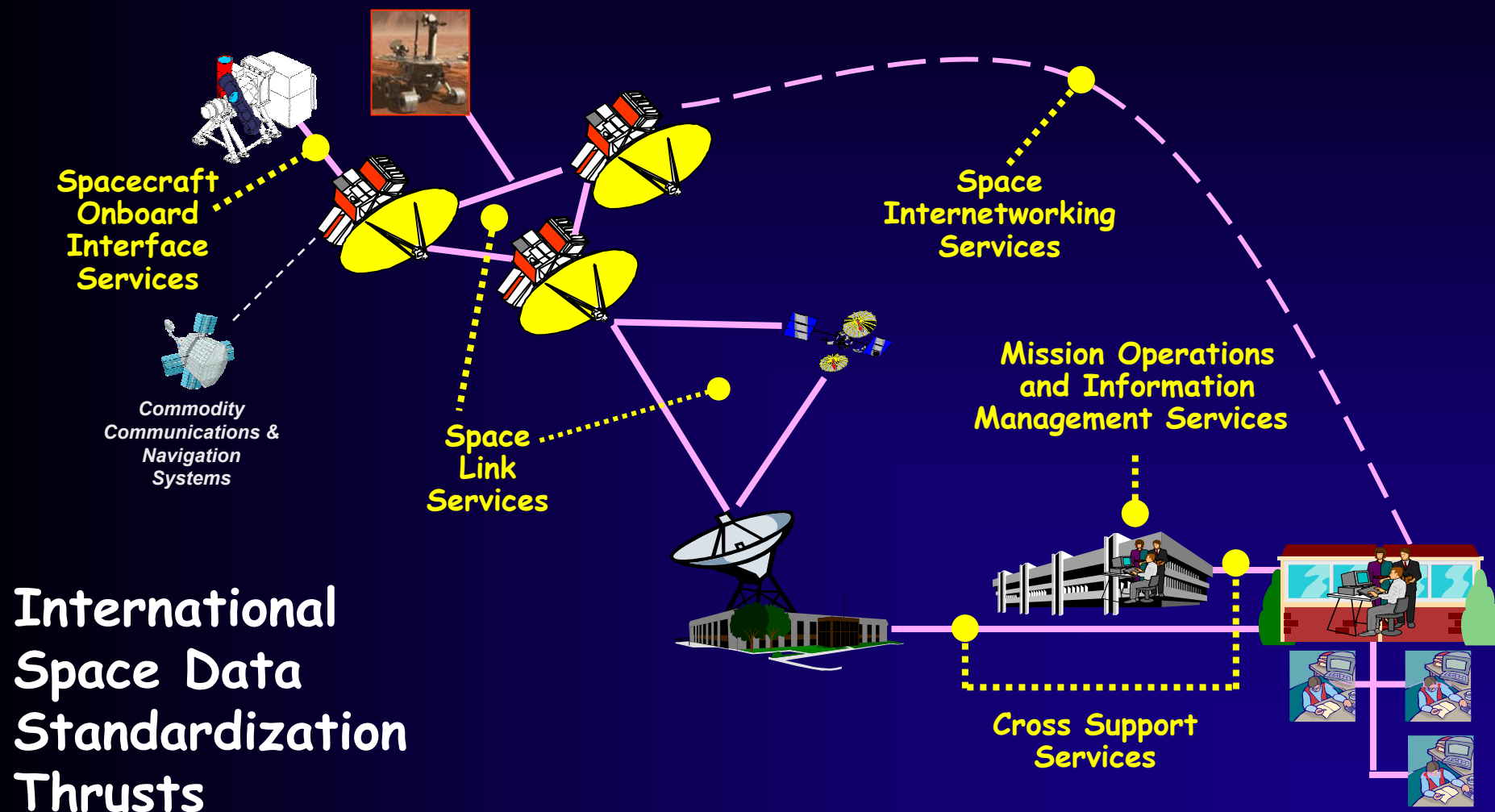


# Space Standards: the CCSDS organization





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# International Space Data Standardization Thrusts

Interplanetary Internet: an architectural  
framework for space internetworking



# CCSDS: The Fleet

Space Domain

Spacecraft Platforms

On-Board Systems

Space Qualified ASICs

**CCSDS**  
Consultative Committee for Space Data Systems

**256 Missions now using  
CCSDS Space Link Protocols**

<http://www.ccsds.org/CCSDS/missions.jsp>

Ground Domain

Commercial Ground Networks

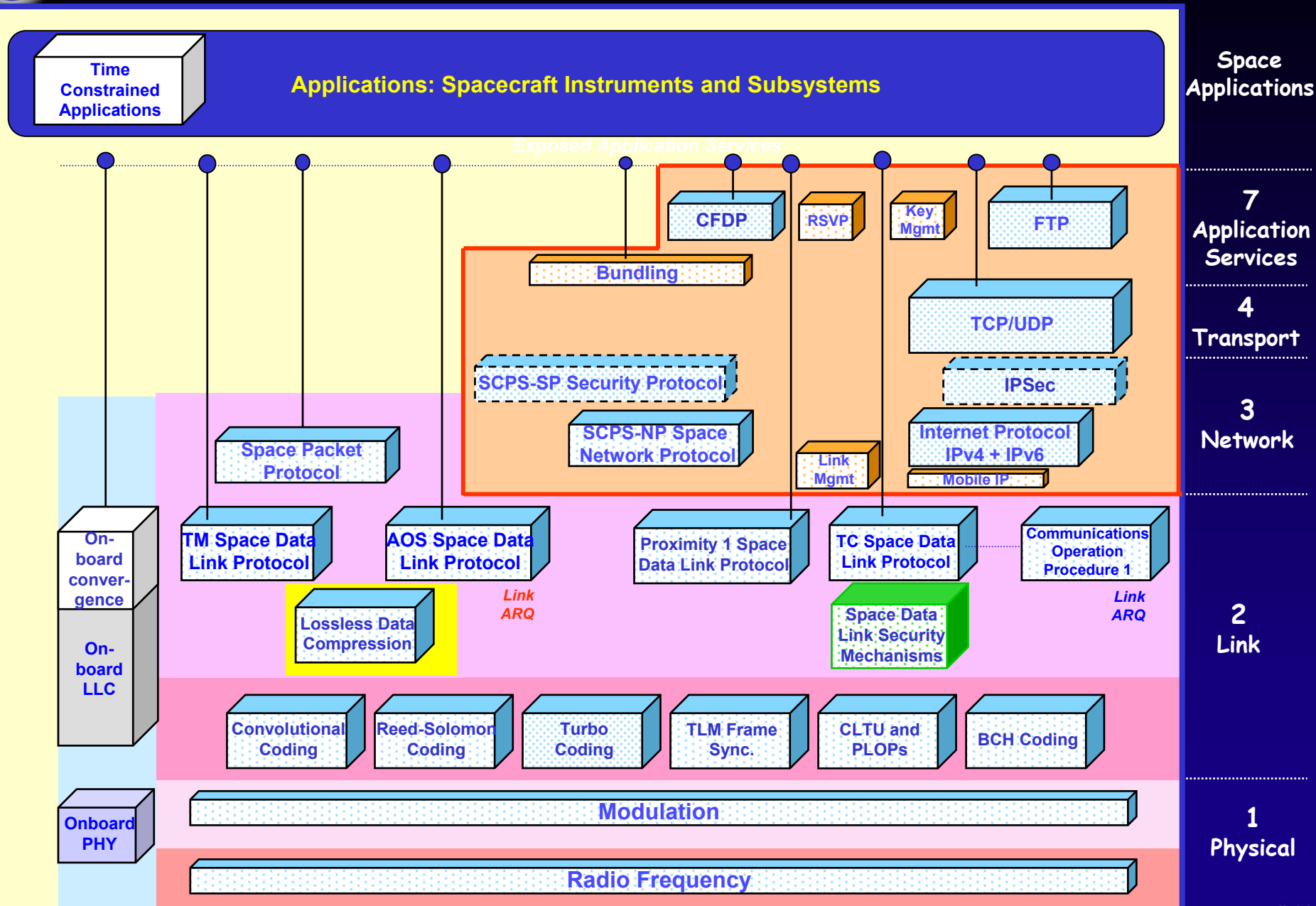
Command & Telemetry Data Processing

Information  
Interchange  
Processes

Shuttle CS Gateway



# Current CCSDS Space Internet Protocol Stack







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  5. Standard Spacecraft Interfaces and IP Network Architectures: Jane Marquart
  6. Standard Transport and Network Capabilities: Bob Durst
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  10. CCSDS Link Layer Protocol Suite: Greg Kazz
- 
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